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# Studies on Spatial Distribution in the Teak Carpenterworm *Cossus cadambae* Moore (Lepidoptera, Cossidae)*

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**Abstract.** *Cossus cadambae* Moore (Lepidoptera, Cossidae) is a relatively new insect pest of teak in India and it has recently assumed major pest status in several plantations in Kerala, Tamil Nadu and Karnataka States. Caterpillars of this insect characteristically bore in the wood of standing trees leading to deterioration of timber. *C. cadambae* has annual generations with an exceptionally prolonged larval stage. At Palappilly, Kerala, where the study was carried out, the generations were continuous and overlapping. The progression of infestation intensity among the trees was studied here. The intensity of attack was studied by scoring the affected trees visually into the following score classes viz., 0 = healthy tree; 1 = low level infestation with a few scattered borer holes; 2 = medium level of infestation with borer holes confined to small groups; 3 = heavy infestation with numerous borer holes in large patches all over the stem and 4 = tree dead as a result of heavy infestation. The results show that during the initial phase of infestation a considerable number of trees in a plantation get affected. The intensity of infestation during this stage remains at a low level (score 1) and usually goes unnoticed since the feeding scars are not often easily detectable. During the subsequent phase of infestation there is a tendency for the already affected trees to get reinfested, besides fresh attack to the unaffected trees in the plantations. As a result there is slow transfer of trees of low intensity score to high intensity classes (score 2, 3, 4) and the affected trees generally occur in distinct patches. As the infestation progresses, further recruitment of attacked trees to higher scores of infestation intensity take place. This phase is characterised by large-scale mortality of the heavily affected trees (score 4). As more and more healthy trees get affected, the infestation becomes more or less uniformly distributed throughout the plantation obliterating the original patchy infestation.

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## Introduction

Teak (*Tectona grandis* Lin.f.) is an important forest tree species raised in extensive plantations in several parts of India, notably in Madhya Pradesh, Andhra Pradesh, Karnataka, Tamil Nadu and Kerala States. In Kerala alone, there are over 60,000 ha. of area planted with this species.

About 140 species of insects are known to attack this tree in the Indian sub region (Nair & Kumar, 1986) although only a few have been reported to cause major damage in plantations. This includes 2 species of follage feeders viz., *Hyblaea puera* Cram. (Hyblaeidae) and *Eutectona machaeralis* Wlk. (Pyraustidae) and a sapling borer *Sahyadrassus malabaricus* Moore (Hepialidae). Recently, outbreaks of a wood boring insect viz., *Cossus cadambae* (Cossidae) have been noticed in several teak plantations in Kerala, Tamil Nadu and Karnataka States in India (Mathew, 1988).

*C. cadambae* mostly attacks mature teak trees. The caterpillars of this insect initially get established in the bark surrounding a wound caused by mechanical injury or in the axillary region of branches (Fig. 1). Subsequently they bore into the sapwood and then into the heartwood. The larval stage lasts for about 8 months and the fully mature larvae measure about 5 cm in size. One caterpillar makes only a single borer hole although heavy infestation over several years can lead to the formation of numerous holes on the wood.

In Kerala, infestation by *C. cadambae* was observed mostly in plantations adjacent to human habitations. Trees growing in such areas were frequently subjected to mechanical damages such as lopping of branches, plucking of leaves etc. Usually, trees along the borders or those standing along the sides of forest tracks were repeatedly subjected to this type of damage. Such trees were often found to be heavily attacked while those occurring in the interior or inaccessable areas were not affected. Mechanical injury leads to the formation of callus growth over wounds or profuse growth of coppices which offer conditions favourable for the establishment of this insect. Beeson (1941) also considered mechanical damage as a factor promoting cossid infestation.

Presently there is no information available on the establishment pattern of this insect in plantations over space and time. Such information is needed for development suitable management strategies and therefore an attempt was made to study this aspect in selected plantations of varying intensity of infestation.

## Materials and Methods

Data for this study were collected from three borer-infested teak plantations in Kerala, which were selected to represent three distinct phases in the establishment of this insect. These phases include (i) an initial stage when the

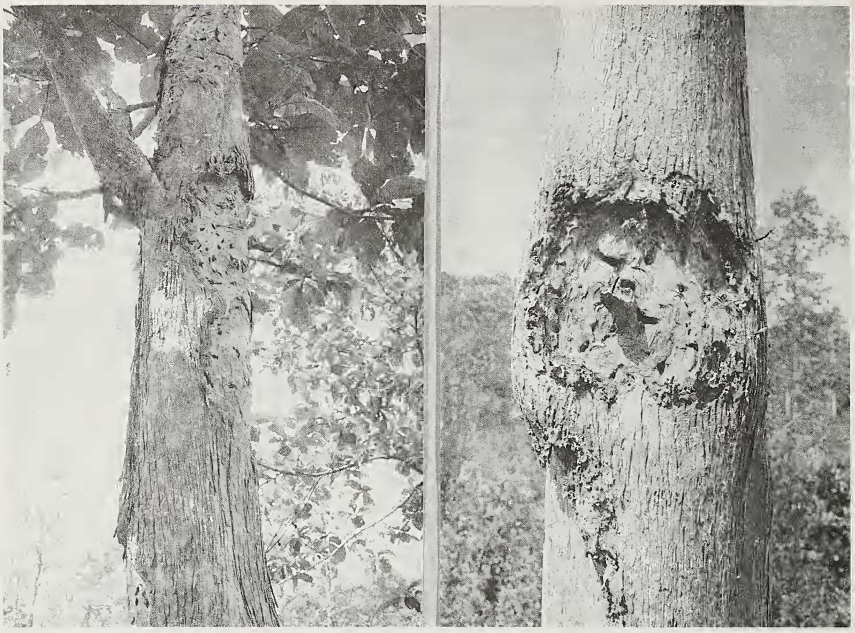

Fig. 1 Trunk of teak showing damage by *C. cadambae*

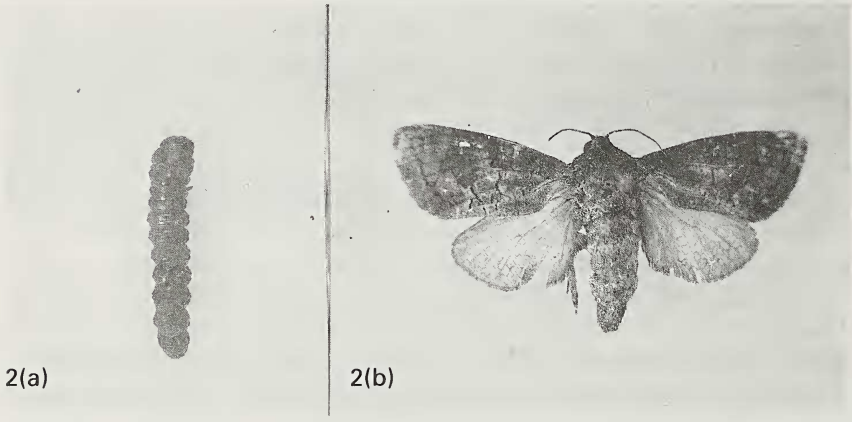


Fig. 2(a) Larva of *C. cadambae*; 2(b) moth

affected trees show only low level infestation, with a few borer holes on the trunk, (ii) an advanced stage of infestation characterised by the formation of several holes on the stem and (iii) a later stage when the damage intensity has substantially increased resulting in many holes on the wood, rendering it unfit for any commercial use. Plantations having the above situations were selected at Parambikulam, Thattakad and Palappilly respectively, based on a sampling survey taking into account the number of affected trees as well as their damage

intensity (Table 2). The intensity of attack was rated by scoring the affected trees visually as given below.

0 = healthy tree
1 = low level of infestation ie., with few scattered borer holes
2 = medium level of infestation with several borer holes usually confined to samll groups
3 = heavy infestation with numerous borer holes in large patches all over the stem
4 = tree dead as a result of heavy infestation

In each of the plantations selected for study, a series of rectangular plots (Table 1) of size 20 m × 8 m were taken linearly extending from one boundary to the other. Each plot contained 34 trees depending on the terrian as well as the extent of disturbance due to various factors like illicit felling, windfall etc. The number of healthy and affected trees as well as the intensity of attack on each of the affected trees was recorded. A negative binomial distribution was fitted to the data on the number of trees affected per plot, in the Parambikulam and Thattaked plantations. Similarly a binomial distribution was fitted to the data on the number of trees affected in the Palappilly plantations. The probability density function of the negative binomial is

$$P(x) = \left(\frac{k + x - 1}{x}\right)\left(\frac{\mu}{k + m}\right)^{x}\left(1 + \frac{\mu}{k}\right)^{-k}$$

where P(x) is the probability of x individuals of a given attribute in the sampling unit
$\mu$ is the location parameter,
k is the dispersion parameter
and that of the binomial is

$$P(x) = \left(\frac{n}{x}\right)^{p^x q^{n-x}}$$

where P is the proportion of the population that shows the attribute q is (1 − p) and n is the maximum number of individuals in the sampling unit.

The parameters in both the cases were estimated through the method of maximum likelihood. The methods given in Bliss and Fisher (1953) were followed in fitting the negative binomial distribution.

## Results and Discussion

Data on the infestation status at the three localities studied herein are given in Table 1. The percentage of affected trees was comparatively low at Parambikulam (19.08%) and Thattaked (17.64%) as compared to that of Palappilly (83.84%). Although the percentage of affected trees in the first two localities were more or less the same, the intensity of infestation in each of these plots was found to vary.

At Parambikulam all the affected trees belonged to a single intensity score class (score 1) while at Thattakad the affected trees belonged to all the four intensity classes. The data for the third locality Palappilly, showed a marked increase in the percentage of affected trees (83.84%).

Table 1. Basic features of the data gathered from 3 localities

| Locality | Number of plots | Total No. of trees | % of trees affected under the various score classes | | | | |
|---|---|---|---|---|---|---|---|
| | | | 0 | 1 | 2 | 3 | 4 |
| Parambikulam | 90 | 414 | 80.92 | 19.08 | – | – | – |
| Thattakad | 90 | 323 | 82.35 | 5.57 | 4.02 | 5.57 | 2.48 |
| Palappilly | 73 | 167 | 16.16 | 6.59 | 11.98 | 26.35 | 38.92 |

Table 2. Estimates of the parameters for the fitted distributions and goodness of fit

| Locality | Variable | Binomial distribution | | Negative binomial distribution | | |
|---|---|---|---|---|---|---|
| | | p | $\chi^2$ | $\mu$ | k | $\chi^2$ |
| Parambikulam | $V_1$ | 0.76 | 3.80 (ns) | | | |
| Thattakad | $V_1$ | 0.72 | 26.18 (**) | | | |
| Palappilly | $V_1$ | 0.46 | 7.79 (ns) | | | |
| Parambikulam | $V_2$ | | | 0.87 | 11.15 | 6.34 (ns) |
| Thattakad | $V_2$ | | | 0.62 | 2.62 | 5.77 (ns) |
| Palappilly | $V_2$ | 0.39 | 5.85 (ns) | | | |

$V_1$ = Number of trees present per plot
$V_2$ = Number of trees affected per plot
ns = non significant
** = significant at 1%

When the relative numbers of affected trees belonging to the various score classes at Thattakad and Palappilly were examined, we found that there was a transformation of the affected trees from the low intensity score to the higher scores with a certain extent of mortality of trees. That is, at Thattakad, out of 17.64% affected trees, only 5.57% belonged to score 1 and the remaining trees belonged to the other score classes (Table 1). Similarly at Palappilly there was a tendency for increase in the number of trees belonging to the high score classes (score 2 = 11.98%, score 3 = 26.35%). The site was also characterised by a high rate of tree mortality (score 4 = 38.92%) and thus only a small percentage of trees belonged to score 1 (score 1 = 6.59%).

The infestations at each of the above localities were very characteristic and illustrated the various phases in the establishment of this insect. The situation observed for Parambikulam represents the initial phase, when the trees show only minimum damage with few borer holes on the trunk. The situation at Thattakad represents the second phase, when the already affected trees were subjected to reinfestation in the subsequent years when the damage became more pronounced often leading to mortality of some trees. In the third phase as represented at

Fig.3a Parambikulam

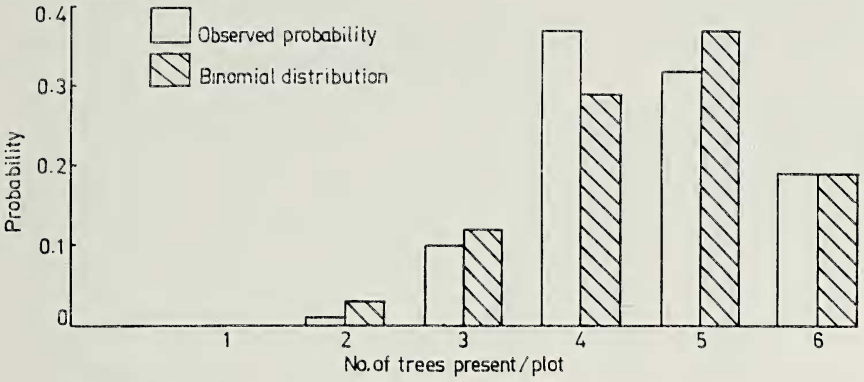


Fig.4a Thattakkad

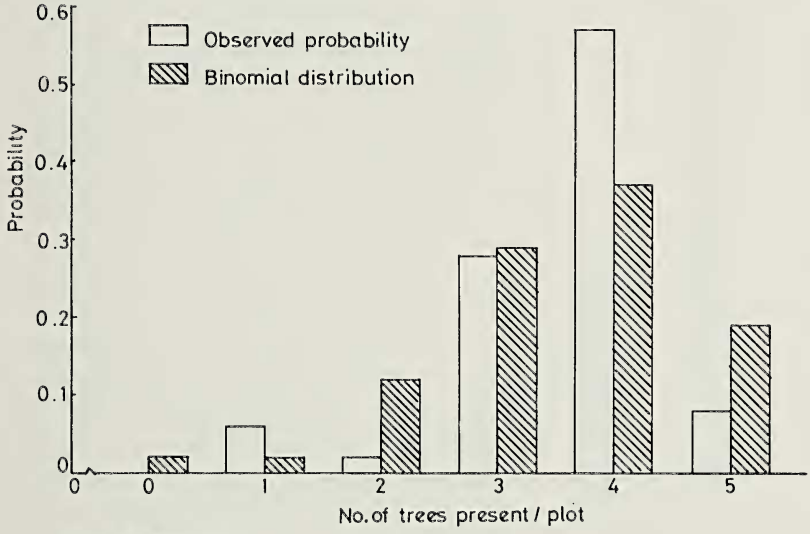


Fig. 5a Palappilly


**Fig. 3a, 4a, 5a** Distribution of number of trees present/plot in Parambikulam, Thattakad and Palappilly.

Fig. 3b Parambikulam

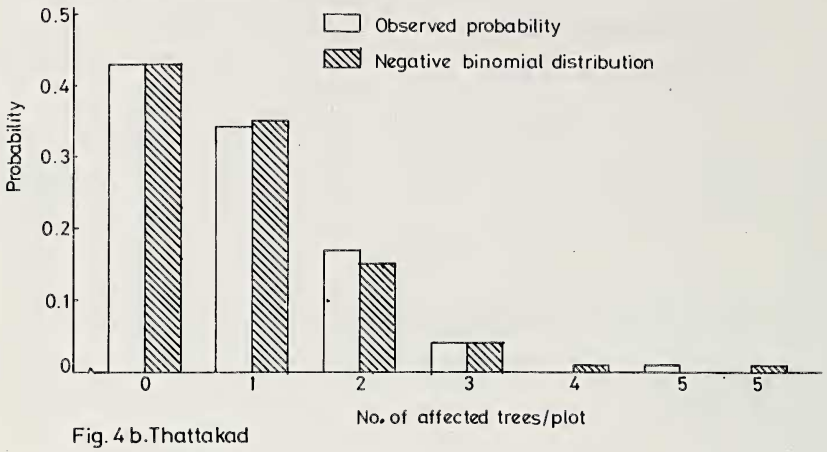


Fig. 4 b.Thattakad

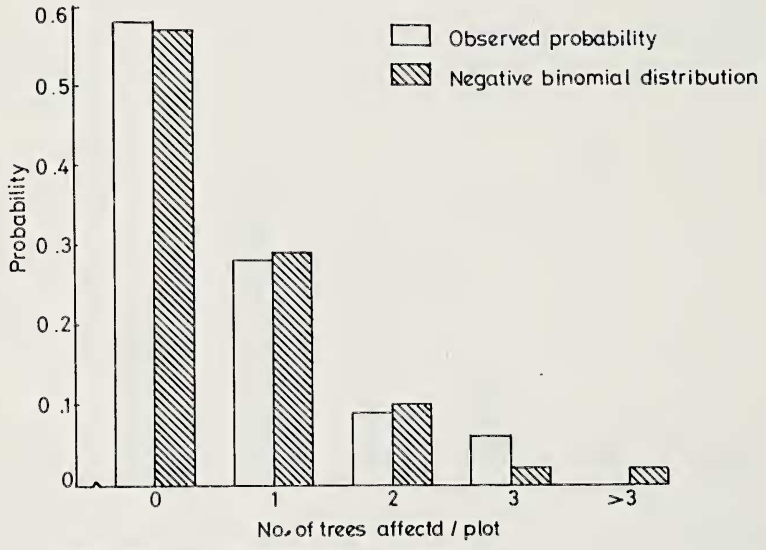


Fig. 5 b Palappilly

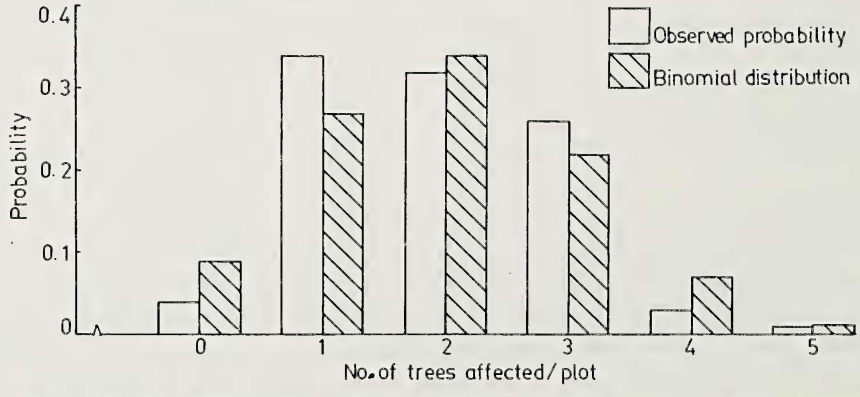


**Fig. 3b, 4b, 5b Distribution of number of trees affected/plot in Parambikulam, Thattakad and Palappilly.**

Palappilly, there was a marked increase in the number of affected trees belonging to higher intensity scores besides fresh attack on the unaffected trees over years resulting in extensive riddling of the timber and subsequent large scale tree mortality.

We studied the distribution of two variables, number of trees present per plot and the number of trees affected per plot, in each of the three localities. The test of independence between the two variables in different plots showed them to be dependent in the case of Palappilly ($\chi^2$ =144.73) and independent in the cases of Thattakad ($\chi^2$ = 5.81) and Parambikulam ($\chi^2$ = 11.86). Therefore it was necessary to study the distribution of variables in the three localities separately. The estimates of the parameters in the fitted distributions are given in Table 2. It indicates that the variable, the number of trees affected per plot, follows negative binomial distribution in the cases of Parambikulam and Thattakad and binomial distribution in the case of Palappilly (Fig. 3b, 4b, 5b). That is, the affected trees occur in definite patches or clusters in Parambikulam and Thattakad, while at Palappilly the affected trees were uniformly distributed. The reason for the uniform distribution of affected trees at Palappilly might be due to the patches of affected trees becoming confluent with the progression in the infestation level over a period of time. The distribution of the number of trees present per plot, was found to be binomial in the case of Parambikulam and Palappilly (Fig. 3a, 5a). However, in the case of Thattakad it was not so (Fig. 4a) probably due to irregularities in the actual frequencies of trees per plot.

The time taken for transformation from one phase of infestation to the other could not be arrived at but it seems that this change is a slow one perhaps requiring several years due to the biology of this insect.

The study has shed some light on the distribution pattern of *C. cadambae* in teak plantations in Kerala under varying levels of infestation status. During the initial phase of attack, the infestation usually goes unnoticed since the feeding scars are usually not very prominent. At this stage a considerable number of trees get attacked. The second phase is characterised by further deterioration of the already affected trees due to reinfestation in the subsequent years leading to slow mortality of trees and by a slow spread of attack to the healthy trees in plantations. During these two phases the affected trees are usually confined to distinct patches. *C. cadambae* being highly mobile organisms can fly to the other parts of the plantation or even to other plantations in the vicinity, resulting in the spread of attack. During the last phase the infestation spreads at a faster pace leading to a high mortality of affected trees and a more or less uniform distribution of attack throughout the plantation.

Due to the behavioural characteristics of this insect, specialised pest management strategies need to be developed for its control in plantations. Since its attack is more clustered in the initial phase, manage-

ment operations need be confined to the affected patches only, rendering control operations more economical.

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